

NEW FORMS OF ENTRY FOR TRANSPORTABLE COLPRO

Sven van der Gijp and Bram Nijboer
TNO Prins Maurits Laboratory
PO box 45, 2280 AA Rijswijk
The Netherlands
gijp@pml.tno.nl

ABSTRACT

Analysis of current available transportable ColPro systems shows that these systems are not designed to cope with the current bio-threat. Therefore, new designs of ColPro have to be created. In these new ColPro designs, the entry of personnel into the containment can be considered as the most critical part. This applies most for transportable ColPro, since the weight, logistic burden and the limited power consumption, which accompanies the use of transportable ColPro, restricts the number of new possible designs. This paper describes the outcome of a recent study on new forms for transportable ColPro and their feasibility.

INTRODUCTION

The current state of the art ColPro is designed to cope with chemical attacks mostly for use in the European region. The way the Royal Netherlands Army currently operates does not correspond with this. First of all the ColPro is going to be used in different climatological conditions. More important is that the threat is changed. Instead of a large-scale conflict, smaller incidents can be expected in which the use of biological agents plays an important role.

The protection offered by the commercial available ColPro must be improved to deal with the current threat. Naturally improvement is possible in the filter, shelter and entry part. Of these three sources the entry seems to be the most critical to address since the pollution of the air, which is introduced inside the ColPro as well as particles. These particles remain on the clothing or body and can be released again (reaerosolisation) to create a threat to the ColPro inhabitants.

The use of ColPro is relatively new for the Dutch Forces. Its added value needs to be proven. New forms of ColPro must be fitted in and adjusted to the peace keeping and enforcing role of the Royal Dutch Army. Therefore, next to protection logistics (a.o. weight, energy) play an important role in the feasibility of solutions. The use of modular ColPro can be a solution. Modular in the way that the ColPro, and especially the entry of ColPro, is adapted to the threat and that not all the components have to be used each time ColPro is employed.

When the airlock is considered it can be seen in figure 1 that under normal conditions it takes quite some time for a person to enter the ColPro. For a protection factor of e.g. 10^8 , an air lock of two m^3 and a flow through the air lock of 300 m^3 it takes a person eight minutes. For this calculation the assumption is made that during the entry the whole air lock is filled with polluted air and that the air inside the air lock is replaced by mixing rather than a plug flow pattern. Reaerosolisation is not considered during the calculation. It should be clear that for rest and relief purposes as well as medical purposes such a long residence time inside the air lock is not suitable considering the number of people who need to enter the ColPro facility or the limited time available for medical reasons.

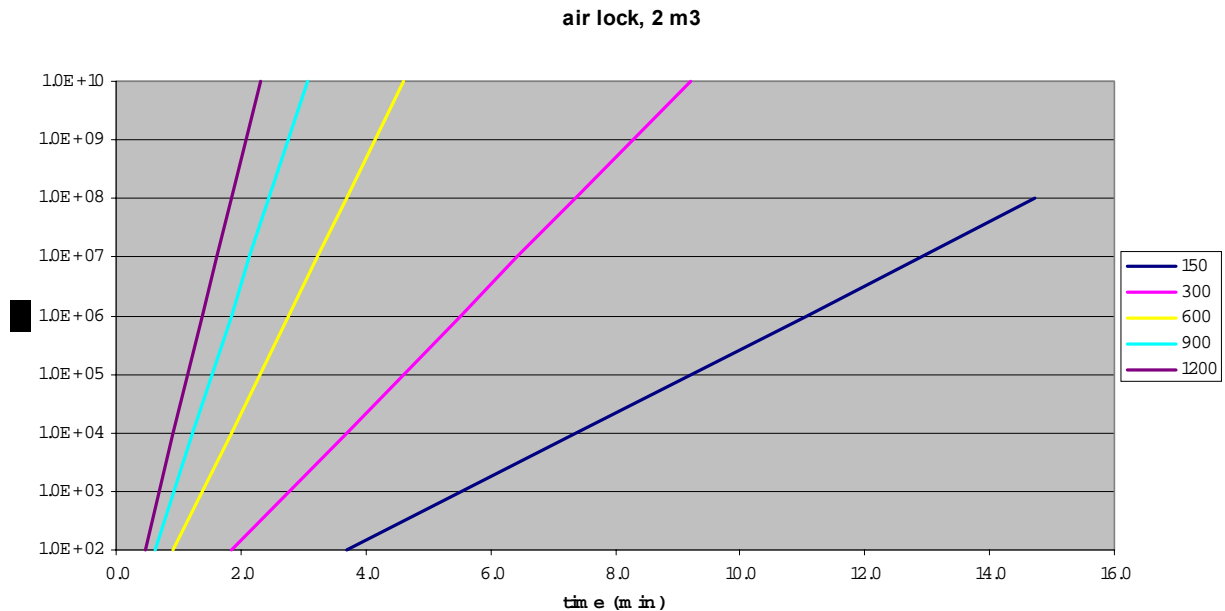


Figure 1. Calculation of the residence time inside an airlock to create given protection factors at various flows. The figures 150 to 1200 are the flow through the air lock (m³/h), PF is Protection factor.

To limit the time in the air lock new creative forms of entry as well as new forms of ColPro were considered during a brain storm session. Afterwards a feasibility study was performed on the various methods for improvement. In the study first of all it was realized that possible improvements in ColPro could be made in the following parts:

- ColPro itself
- Entry
- Residence inside
- Continues decontamination
- Other aids like (improved) detection.

Of these 5 only the first four are considered in this paper. Naturally, the Protection inside a ColPro can never get better than the level provided by the filters, except when internal continuous decontamination techniques are used. Improvement in the protection offered by filters is therefore at least as important as the improvement of entry of the ColPro itself. This paper, however, does not focus on filters neither on seams, connections etc. of the ColPro facility but describes creative solutions for an entire ColPro and especially ways of entry to coop with the new bio-threat.

IMPROVEMENTS TO COLPRO

1. ColPro itself

Naturally avoidance of threat is ideal, if the mobility of ColPro can be improved, than the demands for the protection offered are less decisive. Movement of the ColPro away from danger is ideal. In case of Air Force this might be feasible, for Army, especially during peace missions, this is less likely.

A second way of improving the ColPro is the use of individual ColPro[†]. Advantages of this are that the each person can enter its ColPro and therefore no queuing is required. Waiting time in total is limited and therefore longer residence times per person inside the air lock are less problematic. On the same time no exchange of particles between individuals takes place. One compromised person does not affect the whole ColPro. It should be clear that such a solution is only valid for rest and relief purposes. Another drawback is the huge demand on the logistic chain imposed by such a solution. A compromise can be found in dividing the toxic free area in several compartments, thereby limiting the transfer of bio-agents between the ColPro occupants.

Finally, space or submarine provides solutions in which a perfect containment is kept. In these high-tech. facilities also fresh air is generated or regenerated. Naturally entry does not play an important role in submarine or space. However, currently non-ambulant ways of nitrogen and oxygen production allow for the production of large quantities of air, which can be use for e.g. entry. Although the weight and energy consumption make the use of space and energy techniques not feasible currently on the short term for mobile ColPro, its application might be considered for fixed sites.

2. Entry

As stated above, the entry of ColPro facilities seems to be the most critical since the polluted air, brought along during entry and the particles on a person's body or suit need to be removed. Improvement in ColPro should both focus on the reduction of the amount of polluted air and on possible ways to prevent reaerosolisation. Either stand alone techniques can be used, but also combination of several techniques should be considered.

A quick scan of possible improvements is given below:

- Use of toxic gas
- UV light
- Large air flow
- (Safe) blast
- Vacuum
- Pool with balls or decontaminant
- Fly screen
- Shower
- Radiation

The use of toxic gas like, formaldehyde or ozone might prove to be effective. Naturally, first of all the controlled use of the toxic gas may not impose any harm to the person entering the ColPro. Suitable filters are required or a direct connection between the toxic free area and the mask should be

[†] ColPro is defined as a secure place where an individual is not required to wear individual protection.

established during the exposure to toxic gas. After exposure, it is required to fill the air lock with clean air. Decontamination of particles is very effective for the bulk part of the particles¹. To get rid of all bioparticles requires a lot of time and effort. However, in combination with normal rinsing the use of toxic gas might just speed up the process and limit reaerosolisation.

A somewhat less drastic way of decontamination is the use of a liquid. This can either be in the form of a shower or by using sponge balls. The latter in the form of an air lock filled with balls. The advantage of such is that a large contact area is generated without creating a mess. In addition to the limiting effect on reaerosolisation, the amount of air inside the air lock is reduced also. Both factors improving the protection factor versus time drastically. A drawback of the use of liquid decontaminants is that water based agents spread blister agents very effectively over the body parts, inducing a possible risk on a large surface contamination with severe consequences.

A more drastic approach to liquid decontamination is the use of a pool, or chiffon based lock. By jumping in and out of the pool within ten seconds a protection factor can be achieved of 10^4 . This protection factor is limited due to the fact that when a person jumps into the water a thin second skin of air is formed on the body. Also the air inside the human lung should be considered as a source of polluted air.

Naturally, the use of a pool filled with water as entry has some drawbacks. First there must be enough water available. Next to this the water itself must be prevented from becoming a health risk. Some sort of filtration system could be useful. Naturally, the largest drawback is the degree of acceptance by the user, since he or she becomes wet. Also the entry might generate a somewhat claustrophobic feeling. The protection factor of this type of entry can further be improved by the use of scrubbers that destroy the second skin of air. However, a double water lock in combination with an air lock for cleaning the lung volume can be highly efficient. This efficiency can be increased even further when a decontamination agent is added to the water.

A somewhat easier improvement can already be achieved by limiting the amount of air taken into the air lock. In the worst case all the volume of the air lock is filled with the polluted air. When a person opens a door typically 2 m^3 of air is taken along inside a room. Restricting the opening further, as is visible in figure 2 or by means of a fly screen can limit the amount of air taken inside the airlock and therewith the residence time inside the airlock. This effect is demonstrated in figure 3, where a normal entry is compared with an entry using a fly screen. It must be realized that the only limitation of the airflow itself is not sufficient. The particles on clothing or the body might become airborne again, either inside the airlock or in the toxic free area.



Figure 2. Limitation of the amount of air taken during entering the toxic free area.

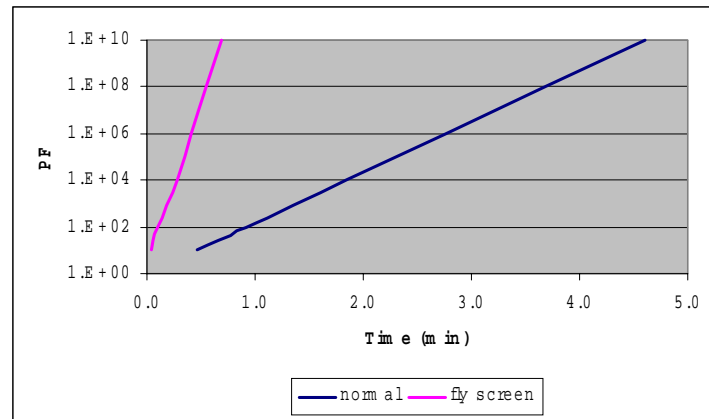


Figure 3. Comparison of the required residence time in an airlock to obtain a given protection factor (PF). Airlock is 2 m^3 , $300 \text{ m}^3/\text{h}$.

For killing the bio-agents on a suit several alternatives exists. Already during the Stockholm conference of 2001, the FOI institute showed that heat could be applied inside the airlock in order to speed up chemical decontamination. Probably the use of heat is insufficient to kill of bioparticles rapidly, radiation, however, could be. Hence the radiation must be strong enough to kill of the bio agents, on the other side the human inside the air lock may not be harmed. A compromise was found in using UVb light. Still this light is harmful; therefore eye protection is required. In addition the method can only be used on suits, not on uncovered skin.

In figure 4 it the results are given of a study where UVb light was used to kill of BG-spores on solid materials. The power required to treat a surface of 20 by 20 cm was 90 Watts. For an air lock this would mean a power consumption of roughly 5000 Watts. Like in the case of decontamination with toxic gas, again most of the bio-agent is killed within the first couple of minutes. Destroying all bio particles requires fare more energy and time.

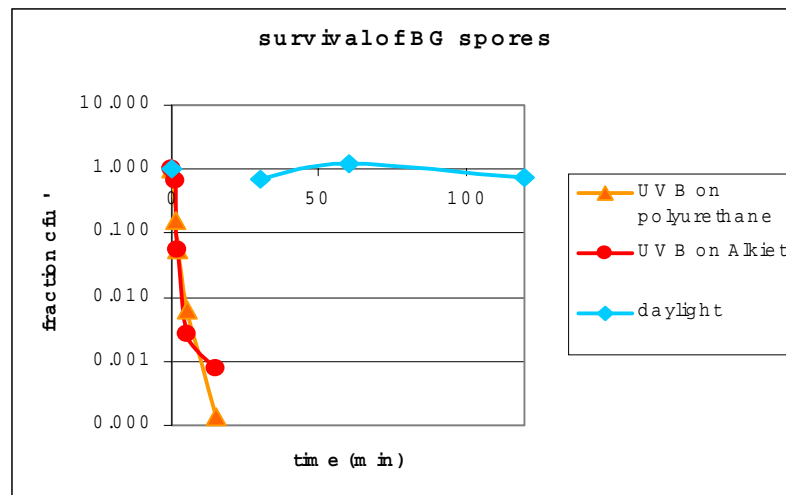


Figure 4. Effect on UVb light on BG spores, cfu is colony forming units.

If no alternatives are available still it can be possible to raise the amount of air flowing through the air lock. This can either be continuously or in the form of a blast. If clothing can be donned carefully the amount of bioparticles released in the air can be limited. A blast or a strong flow can induce the bioaerosols to become airborne again. When less air is used a laminar flow is achieved, creating a plug flow inside the air lock. This proves to be very effective and reduces the residence time in an air lock significantly, see also table 1.

TABLE 1. Calculated effect of airflow on the residence time inside an airlock (size airlock 2m³)

Method	Airflow (m ³ /h)	Time until PF is 10 ⁴ (sec)
Plug flow	300	24
Normal	300	104
Storm	1320	48

Instead of raising the airflow, also vacuum techniques might be useful. Rather than brushing and scrubbing with decontamination agents, the use of a simple vacuum cleaner prevents particles from the suit or body to be released inside the air.

3. Residence inside

When the airlock not sufficient enough to provide adequate protection or when particles are released after entry inside the toxic free area either continuous decontamination can be used or the way of residence inside the toxic free area needs to be adapted to this threat. The residence inside the ColPro can be adapted by using cleanroom suits and facemasks. Naturally this is highly undesired since the purpose of ColPro is to avoid the use of individual protective measures. Still for rest and relief purposes a high comfort face piece might be required to avoid all possible threats. Instead of ColPro suit, a person can also be wrapped in plastic. Naturally this can only be for short times, but maybe an alternative in the case of patients and the absence of proper means of decontamination.

4. Continuous decontamination

As the last resort to get a safe ColPro, continuous decontamination can be use to remove remaining or reaerosolised particles. For the removal of remainders of chemical vapor this is already a normal commercial update of ColPro safety. For the removal of bioagents similar equipment can be used rather easily. Actually more easily, since particulate filters have in contradiction to vapor filers, no limitation in their capacity. Only the resistance when the resistance becomes too high to generate a proper flow filters needs to be changed or maybe washed.

To indicate the pressure drop in the filter a simple control device can be installed, this again in contradiction to vapor filters where still no adequate end of service life indicator exists. Next to the use of filters, also other regenerative techniques like electrostatic precipitation might be considered. Note that these techniques can be used both in the toxic free area as well as inside the air lock, where they can limit the amount of particles in the air which have to be removed.

Although the use of regenerative techniques requires energy, there are to be preferred compared to non-regenerative solutions as wall, ceilings etc. of absorbing materials or charged in order to attract

particles. Finally, the use of agents dispersed in the air inside the toxic free area, to kill bio agents seems impossible since their aggressive nature.

FEASIBILITY

Above already the feasibility of several possible improvements are discussed. However a systematical analysis is required to see which techniques is suitable in transportable ColPro. Important factors are energy, weight, technical feasibility and the effect.

TABLE 2. Feasibility of entry techniques. 1 is good 5 is bad, effect was estimated not measured

Technique	Energy	Weight	Technical Feasibility	Effect	Final Score
fly screen	5	5	5	4	5
pool	4	2	4	3	3
toxic gas	2	2	4	4	3
shower	2	3	3	4	3
individual ColPro	2	2	4	3	3
Large air flow	1	2	4	4	3
containment like space	2	2	2	4	3
UV light	1	2	3	4	3
Vacuum cleaner	1	2	3	4	3
radiation	2	2	2	4	3
safe blast	1	2	2	3	2
pool with balls	2	1	3	2	2

It is clear that easy techniques like the fly screen seem very promising. However, still the reaerosolisation must be addressed. To address this, a shower or the use of toxic gas seems to be an option.

TABLE 3: Feasibility of other possible improvements, 1 is good, 5 is bad; effect was estimated not measured.

Technique	Energy	Weight	Technical Feasibility	Effect	Final Score
compartments	5	2	4	3	4
respiratory products	5	2	4	2	3
wrap	4	2	4	2	3
wall with absorbing material	5	1	5	3	4
recirculation	2	2	5	5	3
electrostatic precipitation	2	2	3	4	3
decontamination mist	5	2	1	3	3

In table 3 it can be seen that generally these techniques are estimated to have a better effect than the entry techniques named in table 2. A lot of the techniques described in table 3 are already more or less achievable or have been achieved already.

CONCLUSIONS

There consist several techniques, based on improvement of the entry or the ColPro itself, to improve the overall protection of ColPro facilities. Some of these techniques are easy achievable, others like e.g. using a water- in stead of an airlock are more difficult. Techniques In general it can be stated that the prevention of reaerosolisation is more difficult to control than the removal of polluted air. Entry techniques using decontamination agents or radiation (UVb) dealing with the prevention of reaerosolisation are difficult to employ in transportable ColPro for reasons of weight and energy consumption but can be highly effective.

REFERENCE

1. Russel, A.D., Hugo, W.B. and Ayliffe, G.A.J.; Principles and practice of disinfection, preservation and sterilization, 2nd edition, 1992.